WHAT IS CLAIMED IS:

1. A method for manufacturing a semiconductor device including a member which is partially silicified, comprising the steps of:

(a) forming a metal film on a semiconductor layer of a substrate;

(b) performing first thermal annealing to cause a silicification reaction between the metal film and the semiconductor layer so as to form a polycrystalline first silicide film on the semiconductor layer;

(c) removing an unreacted portion of the metal film after the step (b);

(d) implanting impurity ions into the first silicide film so as to change the first silicide film into an amorphous second silicide film;

(e) performing second thermal annealing to change the amorphous second silicide film into a polycrystalline third silicide film, the third silicide film being at least a part of the member.

2. The method for manufacturing a semiconductor device of claim 1, wherein the semiconductor layer is a part of a gate electrode of a MISFET, the method further comprising:

a step of depositing a polysilicon film before the step (a); and

a step of forming the gate electrode before or after

the step (a).

3. The method for manufacturing a semiconductor device of claim 1, wherein the semiconductor layer is a part of a source/drain region of a MISFET, the method further comprising, before the step (a):

a step of forming a gate insulative film and a gate electrode on an active region including the semiconductor layer;

a step of forming an insulative side wall on a side surface of the gate electrode; and

a step of forming a source/drain region in each of portions of the active region on both sides of the gate electrode.

4. The method for manufacturing a semiconductor device of claim 1, wherein:

the method further comprises a step of forming a protection film on the substrate after the step (c) and before the step (d); and

in the step (d), ions are implanted into the silicide film via the protection film.

5. The method for manufacturing a semiconductor device of claim 4, wherein the step of forming the protection film is performed at a temperature at which the silicide film does not agglomerate.

6. The method for manufacturing a semiconductor device of claim 4, wherein the step of forming the protection

film is performed at a temperature less than or equal to a temperature of the first thermal annealing.

7. The method for manufacturing a semiconductor device of claim 1, wherein in the step (d), the impurity ions are implanted so as to reach into the semiconductor layer to change a surface portion of the semiconductor layer into an amorphous state.

8. The method for manufacturing a semiconductor device of claim 1, wherein in the step (d), electrically neutral ions are used as the impurity ions.

9. The method for manufacturing a semiconductor device of claim 8, wherein in the step (d), silicon ions are used as the electrically neutral ions.

10. A method for manufacturing a semiconductor device including a member which is partially silicified, comprising the steps of:

(a) forming a first metal film on a semiconductor layer of a substrate;

(b) performing first thermal annealing to cause a silicification reaction between the first metal film and the semiconductor layer so as to form a metal-rich first silicide film on the semiconductor layer;

(c) removing an unreacted portion of the first metal film after the step (b);

(d) depositing a second metal film thinner than the first metal film on the substrate after the step (c);

(e) performing second thermal annealing to form a second silicide film including a portion of the first silicide film that has been changed into a silicon-rich structure and a portion of the second metal film that has been silicified, the second silicide film being at least a part of the member; and

(f) performing third thermal annealing to cause a silicification reaction between the second metal film and the semiconductor layer so as to form a third silicide film on the semiconductor layer.

11. The method for manufacturing a semiconductor device of claim 10, wherein the semiconductor layer is a part of a gate electrode of a MISFET, the method further comprising:

a step of depositing a polysilicon film before the step (a); and

a step of forming the gate electrode before or after the step (a).

12. The method for manufacturing a semiconductor device of claim 10, wherein the semiconductor layer is a part of a source/drain region of a MISFET, the method further comprising, before the step (a):

a step of forming a gate insulative film and a gate electrode on a substrate region including the semiconductor layer;

a step of forming an insulative side wall on a side

surface of the gate electrode; and

a step of forming a source/drain region in each of portions of the substrate region on both sides of the gate electrode.

13. The method for manufacturing a semiconductor device of claim 10, wherein:

the third silicide film is a metal-rich silicide film; and

the method further comprises a step of, after the step (f), performing fourth thermal annealing to change the third silicide film into a silicon-rich fourth silicide film, the second silicide film and the fourth silicide film being at least a part of the member.

14. A method for manufacturing a semiconductor device including a member which is partially silicified, comprising the steps of:

(a) forming a first metal film on a semiconductor layer of a substrate;

(b) performing first thermal annealing to cause a silicification reaction between the first metal film and the semiconductor layer so as to form a metal-rich first silicide film on the semiconductor layer;

(c) removing an unreacted portion of the first metal film after the step (b);

(d) performing second thermal annealing to change the first silicide film into a silicon-rich second silicide film;

(e) depositing a second metal film on the substrate after the step (d);

(f) performing third thermal annealing to cause a silicification reaction between the second metal film and the semiconductor layer so as to form a metal-rich third silicide film on the semiconductor layer; and

(g) performing fourth thermal annealing to change the third silicide film into a silicon-rich fourth silicide film, the second silicide film and the fourth silicide film being at least a part of the member.

15. The method for manufacturing a semiconductor device of claim 14, wherein the semiconductor layer is a part of a gate electrode of a MISFET, the method further comprising:

a step of depositing a polysilicon film before the step (a); and

a step of forming the gate electrode before or after the step (a).

16. The method for manufacturing a semiconductor device of claim 14, wherein the semiconductor layer is a part of a source/drain region of a MISFET, the method further comprising, before the step (a):

a step of forming a gate insulative film and a gate electrode on a substrate region including the semiconductor layer;

a step of forming an insulative side wall on a side

surface of the gate electrode; and

a step of forming a source/drain region in each of portions of the substrate region on both sides of the gate electrode.

17. The method for manufacturing a semiconductor device of claim 14, wherein:

in the step (f), a disruption occurs in the second silicide film when the first silicide film is changed into the second silicide film so that a part of the semiconductor layer is exposed therethrough; and

in the step (g), a silicification reaction is caused between the exposed part of the semiconductor layer and the second metal film.

18. The method for manufacturing a semiconductor device of claim 14, wherein:

in the step (a), a titanium film is formed as the first metal film; and

in the step (g), a cobalt film is formed as the second silicide film.

19. A method for manufacturing a semiconductor device including a member which is partially silicified, comprising the steps of:

(a) forming a metal film whose main component is cobalt on a semiconductor layer of a substrate;

(b) performing first thermal annealing to cause a silicification reaction between the metal film and the

semiconductor layer so as to form a polycrystalline first cobalt silicide film on the semiconductor layer;

(c) removing an unreacted portion of the metal film after the step (b); and

(d) after the step (c), performing second thermal annealing at a temperature of 725°C or less to change the first cobalt silicide film into a second cobalt silicide film, the second cobalt silicide film being at least a part of the member.

20. The method for manufacturing a semiconductor device of claim 19, further comprising:

a step of forming a protection film on the substrate so as to cover the second cobalt silicide film after the step (d); and

a step of performing third thermal annealing at a temperature higher than that of the second thermal annealing, with the second cobalt silicide film being covered by the protection film.

21. A method for manufacturing a semiconductor device including a member which is partially silicified, comprising the steps of:

(a) forming a metal film on a semiconductor layer of a substrate;

(b) performing first thermal annealing to cause a silicification reaction between the metal film and the semiconductor layer so as to form a polycrystalline first

silicide film on the semiconductor layer;

(c) removing an unreacted portion of the metal film after the step (b);

(d) introducing nitrogen into the first silicide film before, in, or after, any of the steps (a) to (c); and

(e) after the step (d), performing second thermal annealing to change the first silicide film into a second silicide film, the second silicide film being at least a part of the member.

22. The method for manufacturing a semiconductor device of claim 21, wherein in the step (d), the nitrogen is introduced so that a nitrogen concentration in the semiconductor layer is $10^{17} \cdot cm^{-3}$ or less after the step (e).

23. The method for manufacturing a semiconductor device of claim 19, wherein the semiconductor layer is a part of a source/drain region of a MISFET, the method further comprising, before the step (a):

a step of forming a gate insulative film and a gate electrode on an active region including the semiconductor layer;

a step of forming an insulative side wall on a side surface of the gate electrode; and

a step of forming a source/drain region by implanting impurity ions into each of portions of the active region on both sides of the gate electrode and then activating the impurity,

wherein the step (d) is performed after the step of forming a source/drain region and before the step (a).

24. The method for manufacturing a semiconductor device of claim 19, further comprising a pre-cleaning step of irradiating a surface of the semiconductor layer with plasma before the step (a),

wherein the step (d) is performed by introducing nitrogen into the semiconductor layer, in advance, by using nitrogen-containing plasma in the pre-cleaning step.

25. A semiconductor device, comprising:

a substrate including a semiconductor layer; and

a silicide layer formed on the semiconductor layer, the silicide layer being obtained by combining together a first metal silicide film and a second metal silicide film.

26. The semiconductor device of claim 25, wherein the semiconductor layer and the silicide layer together form a gate electrode of a MISFET.

27. The semiconductor device of claim 25, wherein the semiconductor layer and the silicide layer together form a source/drain region of a MISFET.

28. The semiconductor device of claim 25, wherein:

the first metal silicide film includes a disruption due to agglomeration of crystal grains; and

the second metal silicide film is formed at least in the disruption in the first metal silicide film.

29. The semiconductor device of claim 25, wherein:

the first metal silicide film is a titanium silicide film; and

the second metal silicide film is a cobalt silicide film.

30. A semiconductor device, comprising:

a substrate including a semiconductor layer; and

a silicide layer formed on the semiconductor layer and containing nitrogen.

31. The semiconductor device of claim 30, wherein the silicide film is a cobalt silicide film.

32. A semiconductor device comprising:

a substrate including a semiconductor layer; and

a silicide layer formed on the semiconductor layer and having a polycrystalline layered structure.

33. The semiconductor device of claim 32, wherein the silicide film is a cobalt silicide film.

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